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**Differences in sauger growth
regimes among three major
areas of Lake Winnipeg.**



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ABSTRACT

Hybrids of saugers, Stizostedion canadense (Smith) and walleyes, Stizostedion vitreum (Mitchill) do not exist in the channel area of Lake Winnipeg. Hybridization does not account for the predominance of larger saugers in the commercial catches of northern Lake Winnipeg. Rather, differences in growth rates, L_{∞} , and proportional growth of saugers among the three major areas of Lake Winnipeg cause the size differences among the commercial catches. Differences in growth regimes are directly related to differences in fishing effort and minimum mesh sizes of the three areas.

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INTRODUCTION

Saugers, Stizostedion canadense (Smith) and walleyes, Stizostedion vitreum (Mitchill) are known to hybridize in nature (Scott and Crossman 1973). Sauger-walleye hybrids can also be artificially propagated (Nelson et al. 1965). Intrapopulation phenotypic variability may be as great as interpopulation variability for both species (Trautman 1957, Paetz and Nelson 1968).

Formerly, hybrid fishes were identified by their phenotypic intermediacy between their predecessors (Hubbs 1955). Two major problems associated with this approach are:

1. it becomes more and more difficult to recognize a hybrid as the phenotypic similarity of the two hybridizing species increases.
2. A species may be phenotypically intermediate to two other species as a result of random selection and not of hybridization.

These problems were overcome by the advent of biochemical analyses of fish tissues. Aspinwall and Tsuyuki (1968), Clayton and Gee (1969) and Nyman (1970) detected parental genetic contributions in filial generations of fish by examining electrophoretic properties of muscle proteins.

The micro starch gel electrophoresis method described by Tsuyuki et al. (1966) is the basic method now used to study electrophoretic properties of fish muscle protein. Using this method, Clayton et al. (1971) revealed six phenotypes of malate dehydrogenase (MDH) isozymes in the skeletal muscle of walleye collected from various Manitoban Lakes. Clayton et al. (1973)

showed that electrophoretic properties of MDH isozymes sampled from walleye and sauger populations can be used as a taxonomic criterion to distinguish the two species and interspecific hybrids.

Clayton et al. (1974) described the geographical distribution of alleles for supernatant MDH in walleye populations of northern Saskatchewan. Uthe and Ryder (1970) described regional variations in walleye muscle myogen polymorphism in Ontario. Schweigert (1976) and Schweigert et al. (1977) used MDH isozyme "tags" to evaluate the effect of fry introduction on abundance, year-class strength and productivity of walleyes in West Blue Lake, Manitoba.

This study was initiated in response to continuing reports of the occurrence of large saugers in the commercial catches of Berens River fishermen. The objectives of this study were:

1. to determine if major differences exist between the sizes of sauger present in various areas of Lake Winnipeg.
2. to determine if sauger-walleye hybrids exist in Lake Winnipeg and if these hybrids are the large saugers that are reported by fishermen.
3. to relate size differences of saugers from various areas to growth of saugers and to fishery effects.

METHODS AND MATERIALS

Twenty-seven stations were sampled on Lake Winnipeg during the summer and autumn of 1979 (Fig. 1). One or two gangs of gill-nets were set once at each station for one overnight period (16-18 hours).

For sets 1 to 26 (Fig. 1), the gillnet gang was composed of the following meshes: 7.62 cm, 8.26 cm, 9.53 cm, 10.80 cm, 12.70 cm and 13.34 cm. For sets 27 to 38 (Fig. 1), the gillnet gang was composed of the following meshes: 7.62 cm, 8.26 cm, 8.89 cm, 9.53 cm, 10.16 cm, and 10.80 cm. Each net in the gang was 45.72 m long and approximately 1.83 m deep.

The fork length of each sauger was measured to the nearest 2 mm. Each sauger was weighed to the nearest 20 gms on a Chatillon spring scale (Chatillon, Mississauga, Ont.). Six to ten scales were collected from the left side of each sauger. Scales were removed above the lateral line below the anterior edge of the dorsal fin. Otoliths were collected from 589 saugers caught in the north end, channel area and south end of Lake Winnipeg.

A sample of white skeletal muscle was collected from each of 484 saugers caught in the northern, channel and southern areas of Lake Winnipeg. Tissue samples were prepared according to Clayton and Gee (1969). Micro starch gel electrophoresis was performed according to Tsuyuki *et al.* (1966). Isozyme visualization was performed according to Clayton *et al.* 1971.

Sauger ages from scales and otoliths were determined according to Erickson (1979).

Routine statistical analyses were performed according to Snedecor and Cochran (1967). Growth analyses were performed according to Ricker (1975). For comparative purposes, data were pooled according to the three main geographical areas of Lake Winnipeg: north-gangs 1-18, channel-gangs 19-26, south-gangs 27-38 (Fig. 1). In fitting growth curves, age-classes containing less than five fish were omitted from analyses.

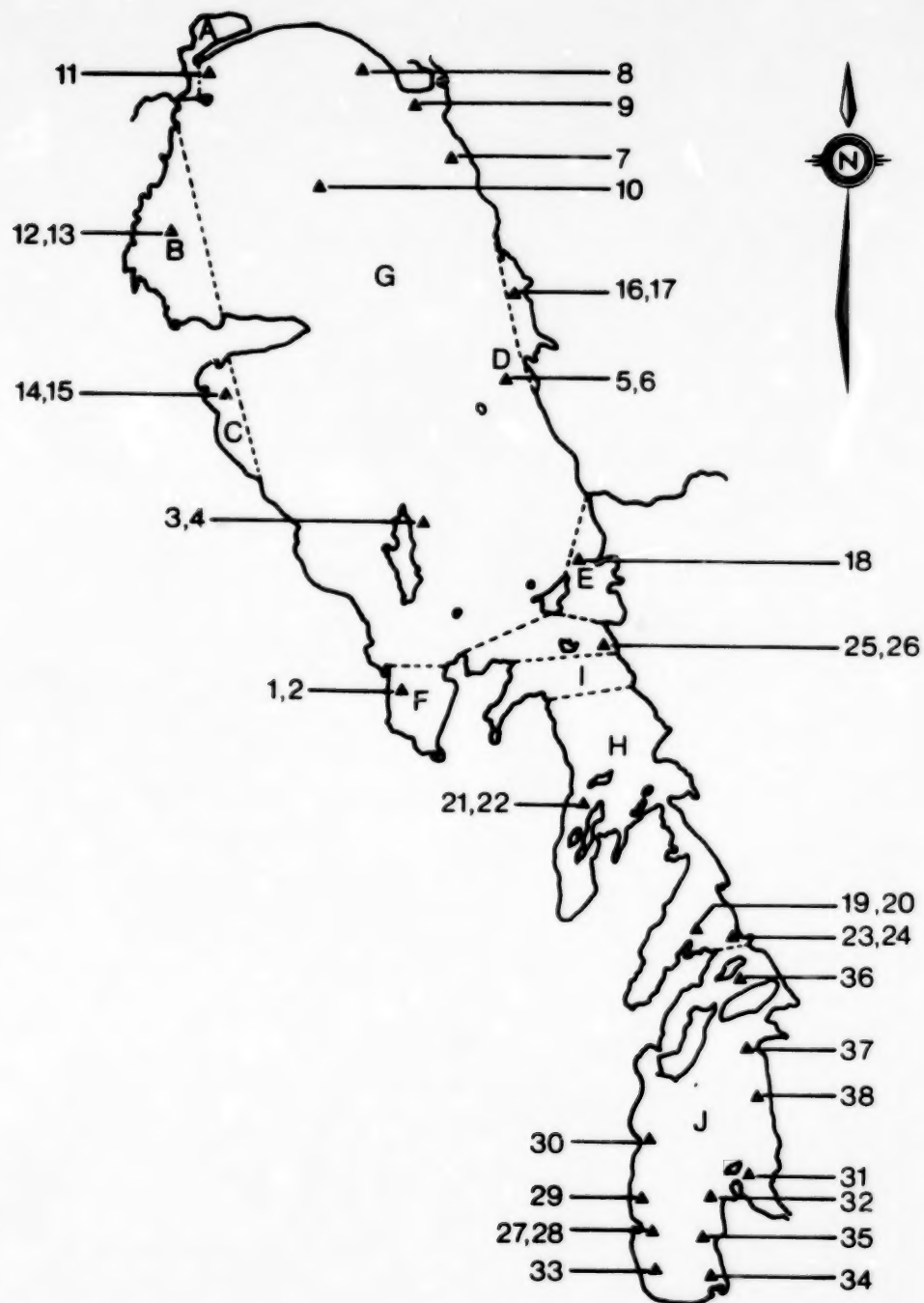


Fig. 1. Locations of sampling stations on Lake Winnipeg. Numbers denote chronological order of gang sets. Areas A-F are management areas of the summer fishery. Gangs 25 & 26 were set in an area where commercial fisheries are prohibited.

RESULTS

481 saugers were characterized by the standard sauger MDH phenotype described by Clayton et al. (1971). Three saugers exhibited a variant of the standard sauger MDH phenotype. No sauger-walleye hybrids as described by Clayton et al. (1971) were observed.

Growth curves of saugers from the southern, channel and northern areas of Lake Winnipeg show obvious size differences among the oldest saugers from each area (Fig. 2, Table 1). Northern saugers attain the largest size at oldest ages.

Walford plots for saugers from the three major areas of Lake Winnipeg (Fig. 3) showed significant relationships of $L_t + 1$ and L_t for southern, channel and northern saugers (Table 2). The L_∞ estimate for southern saugers was lower than the L_∞ estimate for channel saugers. The L_∞ estimate for northern saugers was the highest of all three areas.

Covariance analysis of logtransformed length-weight curves from the three major areas (Fig. 4) showed significant differences among the curves ($F = 4.737$, 2 and 26 d.f., $P = 0.05$). Northern sauger growth is positively allometric while channel and southern growth is negatively allometric (Table 3).

To compare growth rates of southern, channel and northern saugers, two transformations of mean lengths at various ages were tested:

1. In the first case, Von Bertalanffy's growth equation was assumed to represent the growth of saugers:

$$L_t = L_\infty (1 - e^{-k(t - t_0)})$$

where L_t = length at time, t

L_{∞} = maximum length

K = Brody growth coefficient

t_0 = time at which $L = 0$

2. In the second case, it was assumed that the range of age-classes in the samples occupied only a short interval somewhere in the early adult segment of the potential range of ages. Here, it was assumed that a log transformation of age would yield an approximate linear relationship of age and length.

Correlations of length and age (Table 4) indicate that no great increase in degree of linear correlation occurred after transforming the age variable or after transforming according to the Von Bertalanffy growth curve.

Accordingly, an analysis of covariance of untransformed growth curves fitted by least squares regression (Table 5, Fig. 5) showed significant differences in growth rates among saugers from the three major areas of Lake Winnipeg ($F = 3.58$, 2 and 18 d.f., $P = 0.05$).

Otolith ages were significantly different from scale ages for all ages except 2 year old saugers from the south basin (Fig. 6). Differences between otolith ages and scale ages were greatest for northern saugers and were the least for southern saugers (Sample sizes are listed in appendix A).

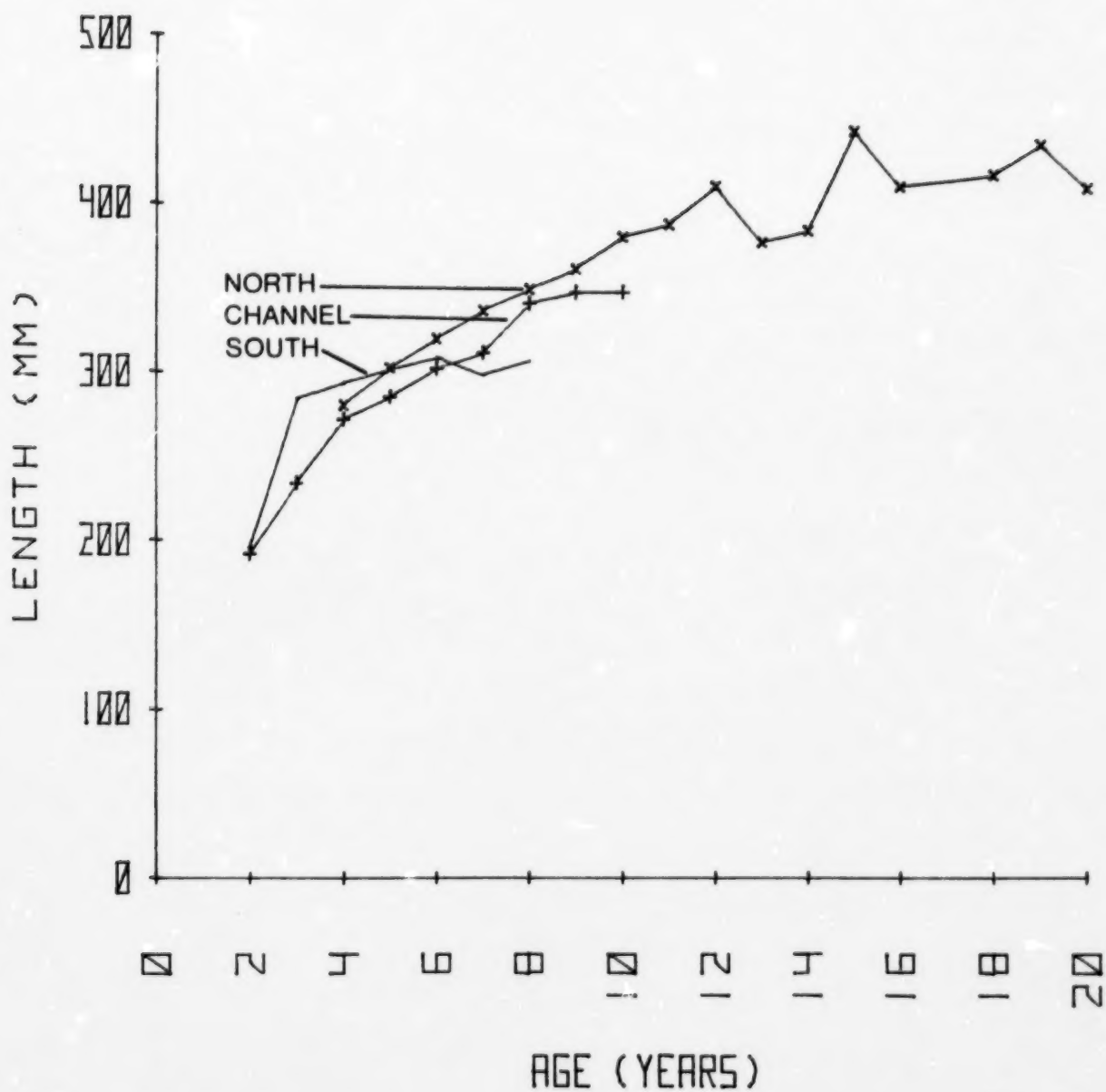


Fig. 2. Growth of saugers from the northern, channel & southern areas of Lake Winnipeg. Ages were determined from scales.

Table 1. Age-specific mean fork lengths and mean weights of saugers from three areas of Lake Winnipeg, 1979.

Age (yrs)	South end			Channel			North end		
	No. fish	Mean length (mm)	Mean weight (gm)	No. fish	Mean length (mm)	Mean weight (gm)	No. fish	Mean length (mm)	Mean weight (gm)
2	16	195.00	97.69	2	191.00	70.00			
3	69	283.22	243.77	21	233.43	123.81			
4	275	292.58	263.76	49	270.98	191.43	8	279.31	273.75
5	268	300.51	286.29	81	284.20	221.85	40	301.28	305.50
6	38	307.55	300.11	28	300.96	270.71	153	318.74	368.76
7	2	297.00	265.00	19	310.26	298.95	223	335.30	430.00
8	1	306.00	350.00	7	339.57	385.71	256	347.77	486.33
9				1	346.00	370.00	179	359.79	541.84
10				1	346.00	380.00	68	378.63	640.15
11							46	386.28	706.09
12							26	408.92	845.00
13							18	375.61	559.44
14							18	382.56	650.00
15							4	441.75	1127.50
16							5	409.20	800.00
17							0	-	-
18							2	416.00	770.00
19							2	434.00	1040.00
20							1	408.00	820.00

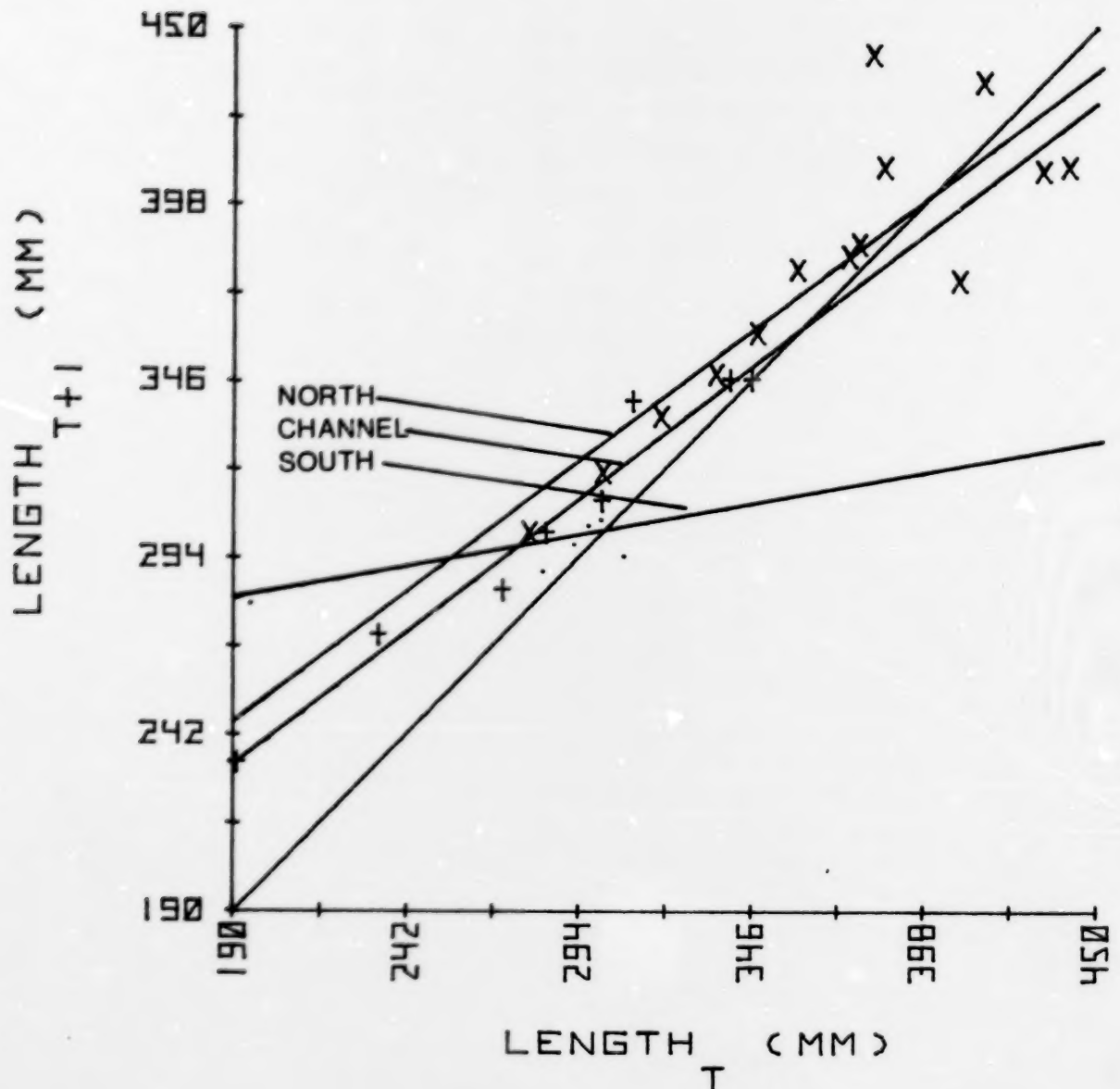


Fig. 3. Walford plots for saugers from the northern, channel and southern areas of Lake Winnipeg.

Table 2. Linear equations of Walford plots fitted by least squares regression.

Lake area	Linear equation	L_{∞} (mm)	Correlation coefficient	Test F value and d.f.	Significance (P = 0.05)
North	$L_t + 1 = 105.526 + 0.738L_t$	402	0.861	34.48 (1,13)	significant
Channel	$L_t + 1 = 90.417 + 0.750L_t$	361	0.980	145.45 (1,7)	significant
South	$L_t + 1 = 248.188 + 0.178L_t$	301	0.826	8.57 (1,5)	significant

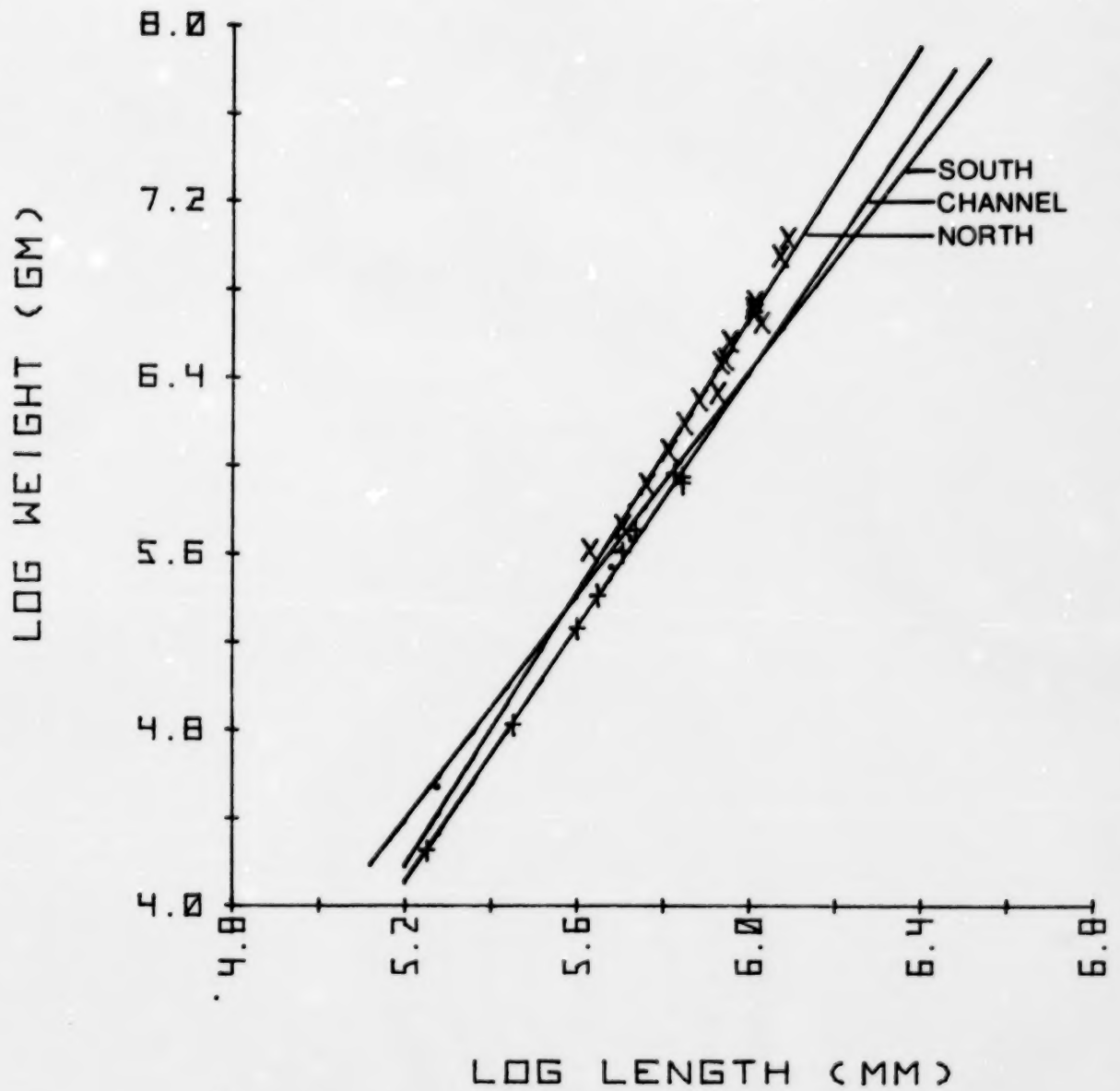


Fig. 4. Length-weight relationships of saugers from the northern, channel and southern areas of Lake Winnipeg.

Table 3. Length-weight relationships of saugers from the southern, channel and northern areas of Lake Winnipeg, 1979.

Lake area	Length-weight equation	Correlation coefficient	Test F value, d.f. and significance at $P = 0.05$
North	$\log_e \text{ weight} = -11.968 + 3.104 \log_e \text{ length}$	0.990	708.1 (1,15) significant
Channel	$\log_e \text{ weight} = -10.940 + 2.893 \log_e \text{ length}$	0.998	2040.86 (1,8) significant
South	$\log_e \text{ weight} = -8.844 + 2.544 \log_e \text{ length}$	0.988	197.14 (1,6) significant

Table 4. Correlation coefficients of untransformed and transformed growth curves.

Lake area	Transformation		
	Untransformed	$\text{Log}_e(\text{age})$	Von Bertalanffy
south	0.832	0.904	0.839
channel	0.980	0.985	0.981
north	0.930	0.951	0.931

Table 5. Southern, channel and northern sauger growth curves fitted by least squares regression.

Lake area	Linear equation	Test F value and d.f.	Significance at P = 0.05
South	$Y = 178.816 + 24.239 X$	6.76 (1,4)	non significant
Channel	$Y = 185.353 + 19.009 X$	97.25 (1,5)	significant
North	$Y = 253.141 + 11.032 X$	70.98 (1,12)	significant

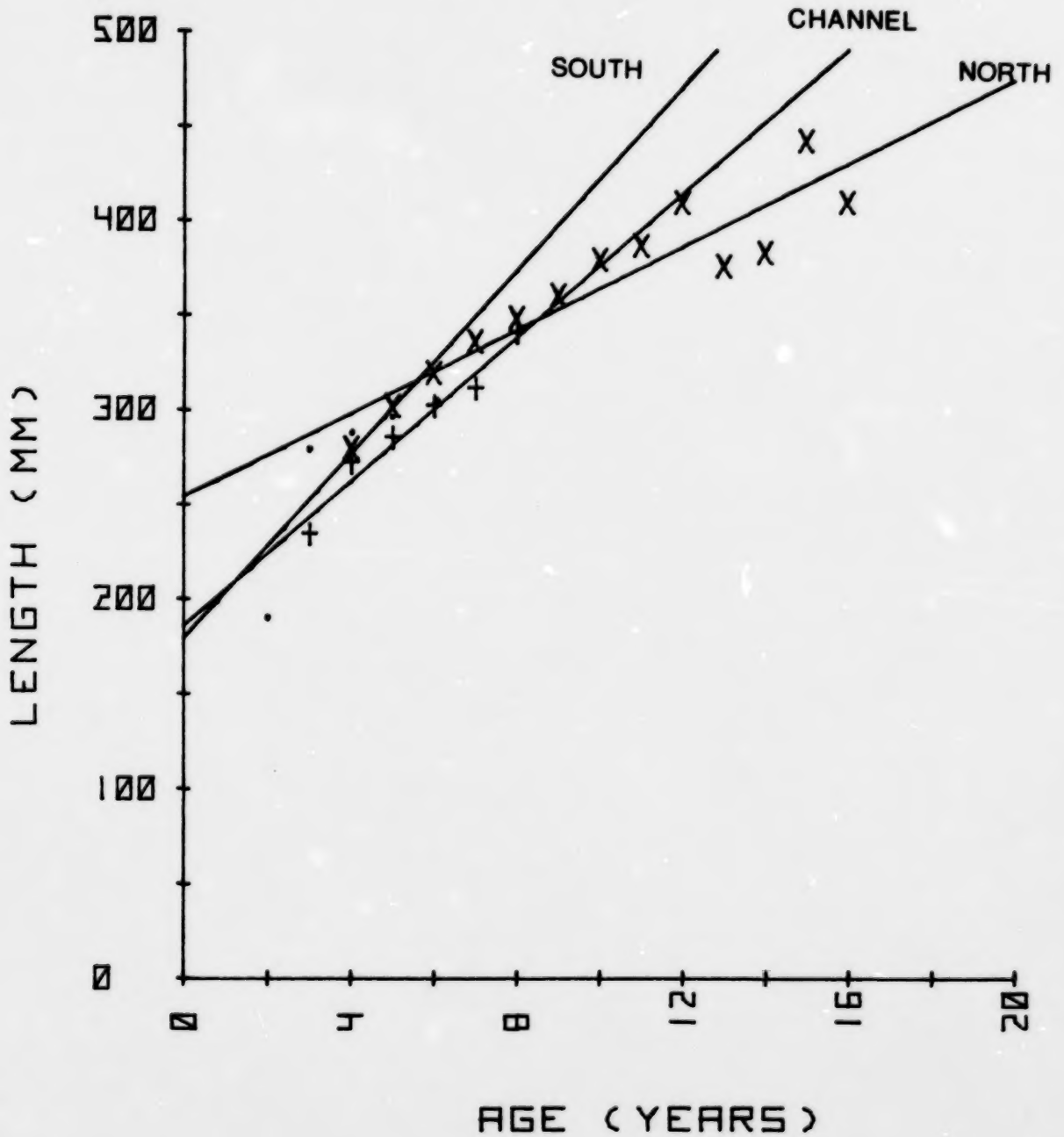


Fig. 5. Growth curves fitted by regression for saugers from the northern, channel and southern areas of Lake Winnipeg.

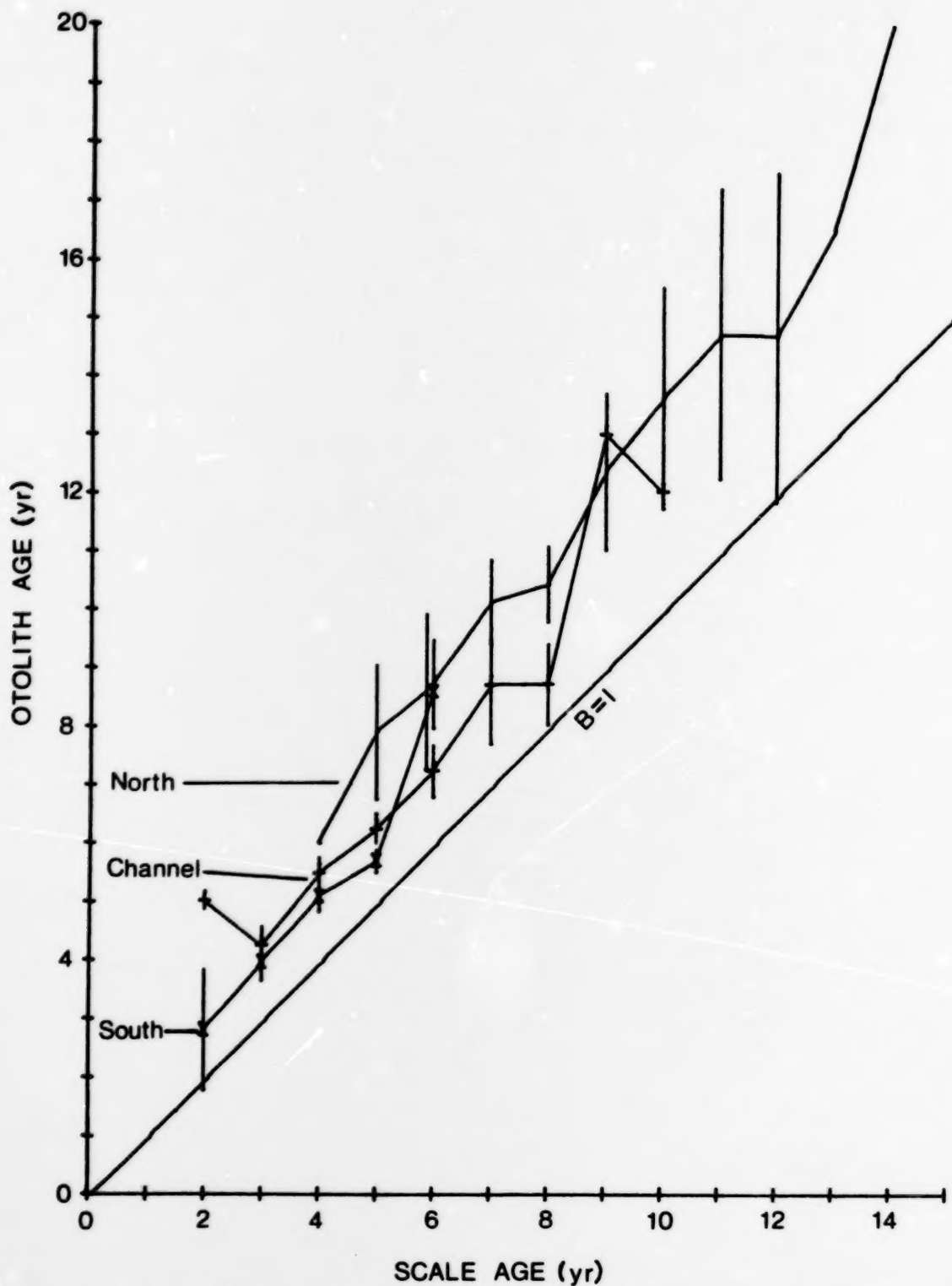


Fig. 6. Differences between scale ages and otolith ages of saugers from the northern, channel and southern areas of Lake Winnipeg. Vertical bars are 95% confidence intervals about the age-specific mean otolith age. The slope of the agreement line is 1.

DISCUSSION

Interspecific hybridization probably does not account for the large saugers caught in the channel and north ends of Lake Winnipeg. The walleye-sauger hybrid MDH electrophoretic pattern (Clayton et al. 1973) was not observed.

The major size difference that exist among saugers caught in the three major areas of Lake Winnipeg can be attributed to regional differences in: growth rates, L_{∞} , proportional growth and levels of commercial exploitation.

Saugers grow fastest in the south basin, at an intermediate rate in the channel area, and slowest in the north basin. Growth curves were fitted to untransformed data because transformations did not increase the correlation coefficients a great deal. Also older fish were underaged using scales (Fig. 6). Underaging fish tends to make a growth curve more linear than it really is.

The trend of decreasing growth rates from the southern to the northern basin was paralleled by increasing L_{∞} estimates. This implies that northern saugers attain larger body sizes than southern saugers. Northern sauger growth is positively allometric while channel and southern sauger growth is negatively allometric. This implies that in addition to attaining the largest body length, northern saugers are also proportionately heavier than channel and southern saugers.

These trends in sauger growth patterns are at least partly a function of differences in commercial exploitation among the three major areas of the lake. The legal minimum mesh size allowed in the

the north basin during open water seasons is 5.0 ". In the Berens and north channel area, 3.75" mesh is legally permitted while fishermen in the south basin are allowed to use 3" mesh nets. The southern fishermen probably remove the majority of saugers that would otherwise grow to be larger than 304 mm. The pre-recruited southern saugers are forced to grow rapidly in response to heavy fishing pressure. Larger minimum mesh sizes and relatively lighter fishing pressure in the channel & northern areas of the lake allow the saugers to attain larger sizes before they are caught. Since fishing pressure is lighter, compensatory increases in growth rates of pre-recruited channel & northern saugers are not as evident as they are in the south basin. Hanford et al. (1977) suggest that since gillnets remove large, proportionately fat fish, selective pressures operate to favour proportionately skinner fish. This may partly explain why southern & channel sauger growth is negatively allometric.

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APPENDIX A

Table A1. Comparison of otolith ages and scale ages of saugers from the three major areas of Lake Winnipeg.

Area	Scale age (years)	Mean otolith age (years)	95% C.I.	Sample size
South	2	2.80	1.76, 3.84	5
	3	3.96	3.63, 4.29	25
	4	5.08	4.83, 5.34	93
	5	5.70	5.51, 5.89	89
	6	8.58	7.24, 9.92	12
	7	6	-	1
	8	8	-	1
Channel	2	5	-	1
	3	4.24	3.89, 4.58	17
	4	5.48	5.20, 5.76	46
	5	6.23	5.97, 6.49	77
	6	7.23	6.77, 7.69	26
	7	8.70	7.70, 9.70	20
	8	8.71	8.02, 9.41	7
	9	13	-	1
	10	12	-	1
North	4	6	-4.89, 16.89	2
	5	7.89	5.73, 9.04	18
	6	8.71	7.94, 9.48	31
	7	10.12	9.40, 10.85	41
	8	10.43	9.77, 11.09	37
	9	12.36	11.01, 13.71	14
	10	13.62	11.71, 15.52	13
	11	14.71	12.23, 17.20	7
	12	14.67	11.84, 17.50	3
	13	16.50	0.16, 32.84	2
	14	20	-	1